Fs 6^{00}

Vertical Waterwheel-Driven Generators

GENERAL ELECTRIC

AUTOMATIC GENERATING STATIONS

There are many small streams that could be developed to deliver electric power economically were it not for the expense of keeping one or more operators at the plant continuously. In the past, this expense has prohibited the development of much valuable water power.

The General Electric Company has overcome this difficulty by providing means for either "full automatic operation" or "remote control" of hydroelectric plants. A great many stations are in service with both systems.

The control equipments for these plants vary widely; some are started and stopped automatically in accordance with water level by means of a float switch; others are started and stopped by an attendant; still others are controlled from a distant point by remote or supervisory control apparatus. Some of these plants have an elaborate control system whereby the units can be started and stopped and the load controlled, with indications of gate opening, water level, etc., at a remote point.

These plants are so designed as to be amply protected against possible short circuit, overheating of the bearings, or other contingencies. They operate successfully without attendants and require only an occasional inspection. The automatic devices are almost human in their operation and are arranged to shut down the station if there is any serious trouble, and allow it to start only when the symptoms of trouble have disappeared.

Automatic and remote-controlled stations, when designed by competent and experienced engineers and equipped with reliable machinery, make possible the economical development of water power that would otherwise run to waste. The operation of these plants has amply justified the confidence placed in G-E engineering and apparatus by managers and engineers wherever electric apparatus is used.

DATA REQUIRED FOR ESTIMATES

When the available horsepower has been determined, the question of number, capacity, and speed of units to be installed should be taken up with the waterwheel builders.

The General Electric Company does not manufacture or sell waterwheels, but is prepared to furnish generators of any size and speed, and to coöperate with any of the waterwheel builders.

Waterwheels may be classified as impulse or tangential type and reaction-turbine type. The horsepower rating of hydraulic turbines is usually given at full gate, although the highest efficiency occurs at part gate (0.85 to 0.95 gate). In selecting the proper size of generator, the horsepower at these two values as well as generator efficiency should be considered.

The following information should, if possible, be given on all requests for vertical waterwheel-driven generators:

1. Net effective head.
2. Maximum horsepower of turbine.
3. Horsepower of turbine at maximum efficiency.
4. Normal speed of turbine.
5. Runaway speed of turbine.
6. Weight of waterwheel runner and shaft, and water thrust.
7. Minimum WR^2 (flywheel effect).
8. Diameter of largest piece of turbine to be removed through concrete foundations or generator floor.
9. Kv-a. rating, power-factor, frequency, phase, and voltage of generator.
10. Method of excitation (direct-connected or motor-driven).

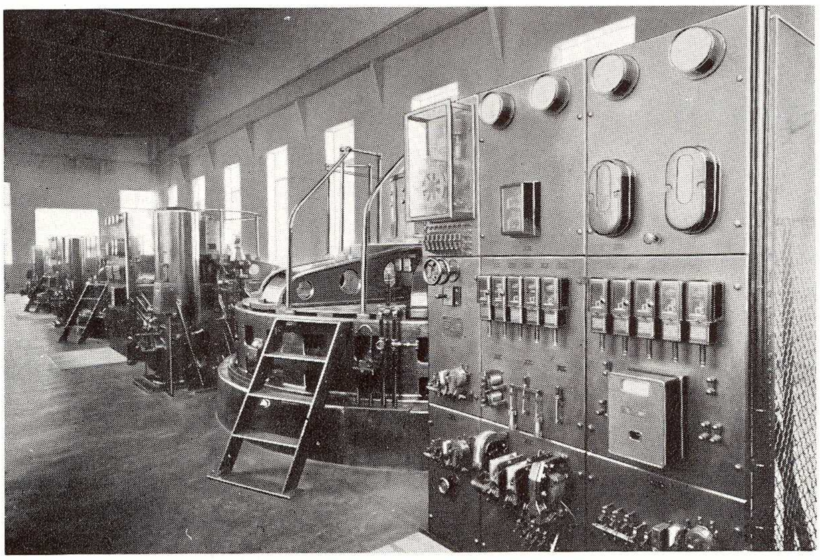

Fig. 11. Three 1750-kv-a., 112.5-rpm., 2300-volt Generators with Automatic Control, Wisconsin Valley Electric Company, Merrill, Wis.

The selection of a generator is found by the formula

$$KV\text{-}A. = \frac{HP \times 0.746 \times E \times 0.95}{P\text{-}F.}$$

in which $P\text{-}F.$ = power-factor, usually 0.8
E = generator efficiency
0.746 = constant for relation of hp. to kw.
0.95 = per cent of power at best operating point of turbine.

Flywheel Effect

$$WR^2 = \frac{81 \times 10^6 \times HP. \times T}{D \times (RPM.)^2}$$

where WR^2 = flywheel effect in pounds feet squared
81×10^6 = constant
T = time in seconds of governor operation
T = 1½ to 2 sec. for open flume
2 to 5 sec. for pipe lines
D = per cent of speed change or regulation

Example: Desired to find the WR^2 required for 25 per cent regulation of a 500-hp. turbine running at 150 rpm. in an open flume with a one-second governor.

Then $$WR^2 = \frac{81 \times 10^6 \times 500 \times 1}{25 \times 150^2} = 72{,}000$$

SPEED, POWER, QUANTITY

The speed (RPM.) of a given runner is in direct proportion to the square root of its operating head or $\sqrt{H}$

The power of a given runner is, at any definite gate opening, in direct proportion to the square root of the head cubed or $H^{\frac{3}{2}}$.

The quantity of water of a given runner is in direct proportion to the square root of the head or $\sqrt{H}$

Example: Having a 316-hp. turbine operating at a head of 20 ft. at 248 rpm. and discharging 168 cu. ft. per sec., it is desired to find the power, speed, and discharge at 25 ft. head. From the above:

$$S' = \frac{S \times \sqrt{H'}}{\sqrt{H}} = \frac{248 \times \sqrt{25}}{\sqrt{20}} = 278 \text{ rpm.}$$

$$P' = \frac{P \times H'^3}{H^{\frac{3}{2}}} = \frac{316 \times 25^{\frac{3}{2}}}{20^{\frac{3}{2}}} = 442 \text{ bhp.}$$

$$Q' = \frac{Q \times \sqrt{H'}}{\sqrt{H}} = \frac{168 \times \sqrt{25}}{\sqrt{20}} = 188 \text{ cu. ft. per sec.}$$

In the same manner all reading may be reduced to a constant head of 1 ft. and the specific speed and power derived. Tables of squares and three-half powers are given as well as the general conversion tables to assist in making preliminary calculations.

TABLE OF $H^{\frac{3}{2}}$ FOR CALCULATING HORSEPOWER OF TURBINES

Original by Robert E. Horton (Copyrighted 1914)

H	0.0	1	2	3	4	5	6	7	8	9
0	0.0000	0.0316	0.0894	0.1643	0.2530	0.3536	0.4648	0.5857	0.7155	0.8538
1	1.0000	1.1537	1.3145	1.4822	1.6565	1.8371	2.0238	2.2165	2.4150	2.6190
2	2.8284	3.0432	3.2631	3.4881	3.7181	3.9529	4.1924	4.4366	4.6853	4.9385
3	5.1962	5.4581	5.7243	5.9947	6.2693	6.5479	6.8305	7.1171	7.4076	7.7019
4	8.0000	8.3019	8.6074	8.9167	9.2295	9.5459	9.8659	10.1894	10.5163	10.8466
5	11.1803	11.5174	11.8578	12.2015	12.5485	12.8986	13.2520	13.6086	13.9682	14.3311
6	14.6969	15.0659	15.4379	15.8129	16.1909	16.5718	16.9557	17.3425	17.7322	18.1248
7	18.5203	18.9185	19.3196	19.7235	20.1302	20.5396	20.9518	21.3666	21.7842	22.2045
8	22.6274	23.0530	23.4812	23.9121	24.3455	24.7815	25.2202	25.6613	26.1050	26.5523
9	27.0000	27.4512	27.9050	28.3612	28.8199	29.2810	29.7445	30.2105	30.6789	31.1496
10	31.6228	32.0983	32.5762	33.0564	33.5390	34.0239	34.5111	35.0006	35.4924	35.9865
11	36.4829	36.9815	37.4824	37.9855	38.4908	38.9984	39.5082	40.0202	40.5343	41.0507
12	41.5692	42.0910	42.6128	43.1388	43.6648	44.1952	44.7256	45.2600	45.7944	46.3332
13	46.8720	47.4148	47.9576	48.5048	49.0520	49.6032	50.1544	50.7096	51.2648	51.8240
14	52.3832	52.9464	53.5096	54.0768	54.6440	55.2152	55.7864	56.3616	56.9368	57.5156
15	58.0944	58.6776	59.2608	59.8472	60.4336	61.0244	61.6152	62.2096	62.8040	63.4020
16	64.0000	64.6020	65.2040	65.8096	66.4152	67.0244	67.6336	68.2464	68.8592	69.4760
17	70.0928	70.7132	71.3336	71.9572	72.5808	73.2084	73.8360	74.4672	75.0984	75.7328
18	76.3672	77.0056	77.6440	78.2856	78.9272	79.5724	80.2176	80.8664	81.5152	82.1672
19	82.8192	83.4748	84.1304	84.7892	85.4480	86.1104	86.7728	87.4384	88.1040	88.7732
20	89.4424	90.1152	90.7880	91.4636	92.1392	92.8184	93.4976	94.1800	94.8624	95.5484
21	96.2344	96.9232	97.6120	98.3044	98.9968	99.6924	100.3880	101.0868	101.7856	102.4872
22	103.1888	103.8940	104.6008	105.3076	106.0160	106.7276	107.4392	108.1540	108.8688	109.5864
23	110.3040	111.0248	111.7456	112.4700	113.1944	113.9216	114.6488	115.3788	116.1088	116.8420
24	117.5752	118.3128	119.0496	119.7876	120.5272	121.2696	122.0120	122.7576	123.5032	124.2516
25	125.0000	125.7516	126.5032	127.2576	128.0120	128.7706	129.5292	130.2876	131.0480	131.8112
26	132.5744	133.3408	134.1072	134.8764	135.6456	136.4180	137.1904	137.9652	138.7400	139.5180
27	140.2960	141.0768	141.8576	142.6416	143.4256	144.2120	144.9984	145.7880	146.5776	147.3700
28	148.1624	148.9572	149.7520	150.5500	151.3480	152.1488	152.9496	153.7532	154.5568	155.3632
29	156.1606	156.9788	157.7880	158.6000	159.4120	160.2268	161.0416	161.8588	162.6760	163.4964
30	164.3168	165.1396	165.9624	166.7884	167.6144	168.4428	169.2712	170.1020	170.9328	171.7668
31	172.6008	173.4372	174.2736	175.1128	175.9520	176.7940	177.6360	178.4804	179.3248	180.1720
32	181.0192	181.8692	182.7192	183.5716	184.4240	185.2792	186.1344	186.9920	187.8496	188.7100
33	189.5704	190.4336	191.2968	192.1624	193.0280	193.8960	194.7640	195.6348	196.5056	197.3788
34	198.2520	199.1460	200.0400	200.9008	201.7616	202.6424	203.5232	204.4068	205.2904	206.1764
35	207.0624	207.9512	208.8400	209.7312	210.6224	211.5204	212.4184	213.3104	214.2024	215.1012
36	216.0000	216.9012	217.8024	218.7060	219.6096	220.5760	221.4224	222.3312	223.2400	224.1512
37	225.0624	225.9760	226.8896	227.8056	228.7216	229.6404	230.5592	231.4800	232.4008	233.3244
38	234.2480	235.1736	236.0922	237.0276	237.9560	238.8868	239.8176	240.7508	241.6840	242.6196
39	243.5552	244.4932	245.4312	246.3712	247.3112	248.2540	249.1968	250.1420	251.0872	252.0348
40	252.9824	253.9320	254.8816	255.8340	256.7864	257.7412	258.6960	259.6528	260.6096	261.5688
41	262.5280	263.4896	264.4512	265.4152	266.3792	267.3456	268.3120	269.2804	270.2488	271.2200
42	272.1912	273.1644	274.1376	275.1132	276.0888	277.0672	278.0456	279.6252	280.0048	280.9872
43	281.9696	282.9544	283.9392	284.9264	285.9136	286.9028	287.8920	288.8836	289.8752	290.8692
44	291.8632	292.8597	293.8552	294.8536	295.8520	296.8528	297.8536	298.8564	299.8592	300.8640
45	301.8688	302.8764	303.8840	304.8936	305.9032	306.9148	307.9264	308.9404	309.9544	310.9708
46	311.9872	313.0056	314.0240	315.0448	316.0658	317.0884	318.1112	319.0556	320.0000	321.1080
47	322.2160	323.2452	324.2744	325.3060	326.3376	327.3716	328.4056	329.4416	330.4776	331.5156
48	332.5536	333.5927	334.6333	335.4753	336.7188	337.7588	338.8051	339.8529	340.8972	341.9479
49	343.0000	344.0486	345.0986	346.1500	347.2079	348.2622	349.3179	350.3750	351.4336	352.4886
50	353.5500	354.6128	355.6720	356.7376	357.7996	358.8681	359.9329	360.9992	362.0719	363.1409

TABLE OF $H^{\frac{3}{2}}$ FOR CALCULATING HORSEPOWER OF TURBINES (*Cont.*)

H	0.0	1	2	3	4	5	6	7	8	9
51	364.2114	365.2832	366.3564	367.4311	368.5020	369.5794	370.6582	371.7333	372.8149	373.8927
52	374.9772	376.0578	377.1397	378.2331	379.3078	380.3940	381.4815	382.5703	383.6606	384.7522
53	385.8453	386.9343	388.0301	389.1219	390.2205	391.3150	392.4163	393.5136	394.6122	395.7122
54	396.8136	397.9163	399.0204	400.1258	401.2326	402.3408	403.4448	404.5557	405.6679	406.7759
55	407.8855	409.0017	410.1139	411.2273	412.3477	413.4639	414.5814	415.7002	416.8204	417.9419
56	419.0648	420.1833	421.3089	422.4257	423.5583	424.6879	425.8131	426.9453	428.0732	429.2080
57	430.3386	431.4704	432.6036	433.7380	434.8738	436.0110	437.1494	438.2892	439.4302	440.5726
58	441.7106	442.8556	443.9961	445.1438	446.2869	447.4372	448.5830	449.7300	450.8842	452.0330
59	454.0849	455.3271	455.4907	456.6455	457.8017	458.9592	460.1179	461.2720	462.4334	463.5960
60	464.7540	465.9192	467.0797	468.2475	469.4106	470.5750	471.7467	472.9137	474.0819	475.2514
61	476.4222	477.3942	478.7676	479.9422	481.1181	482.2891	483.4676	484.6473	485.8222	487.0044
62	488.1880	489.3666	490.5465	491.7339	492.9163	494.1000	495.2912	496.4774	497.6648	498.8536
63	500.0436	501.2348	502.4273	503.6211	504.8161	506.0061	507.2036	508.4024	509.5961	510.7974
64	512.0000	513.1974	514.3960	515.6024	516.8035	518.0059	519.2160	520.4209	521.6270	522.8344
65	524.0430	525.2528	526.4639	527.6762	528.8898	530.1046	531.3120	532.5313	533.7498	534.9630
66	536.1840	537.2996	538.6230	539.8411	541.0670	542.2875	543.5092	544.7389	545.9630	547.1884
67	548.4151	549.4629	550.8720	552.1022	553.3337	554.5665	555.6179	557.0356	558.2652	559.5027
68	560.7416	561.9748	563.2160	564.4516	565.6953	566.9334	568.1795	569.4199	570.6616	571.9113
69	573.1554	574.4006	575.6473	576.8947	578.1436	579.3937	580.6449	581.8974	583.1510	584.4059
70	585.6620	586.9122	588.1707	589.4303	590.6841	591.9462	593.2023	594.4668	595.7253	596.9921
71	598.2531	599.5152	600.7856	602.0506	603.3157	604.5825	605.8505	607.1197	608.3901	609.6616
72	610.9344	612.2083	613.4340	614.7596	616.0371	617.3085	618.5883	619.8692	621.0841	622.4274
73	623.7120	624.9903	626.2699	627.5579	628.8398	630.1302	631.4144	632.6997	633.9862	635.2813
74	636.5702	637.8602	639.1513	640.4437	641.7372	643.0318	644.3276	645.6246	646.9152	648.2145
75	649.5150	650.8166	652.1118	653.4157	654.7208	656.0195	657.3268	658.6278	659.9375	661.2408
76	662.5452	663.8583	665.1650	666.4728	667.7894	669.0996	670.4108	671.7131	673.0368	674.3514
77	675.6673	676.9842	677.2043	679.6216	680.9419	682.2635	683.5784	684.9021	686.2271	687.5454
78	688.8726	690.2009	691.5226	692.8532	694.1771	695.5100	696.8361	698.1713	699.4997	700.8292
79	702.1599	703.4995	704.8324	706.1665	707.5016	708.8379	710.1752	711.5137	712.8534	714.1941
80	715.5360	716.8789	718.2230	719.5683	720.9146	722.2540	723.6026	724.9523	726.2950	727.6496
81	729.0000	730.3460	731.7613	733.0495	734.3989	735.7575	737.1091	738.4699	739.8237	741.1876
82	742.5346	743.8998	745.2580	746.6173	747.9776	749.3392	750.7018	752.0655	753.4303	754.7962
83	756.1632	757.5312	758.9004	760.2624	761.6338	763.0063	764.3798	765.7461	767.1219	768.4904
84	769.8684	771.2474	772.6192	774.0004	775.3743	776.7493	778.1338	779.5110	780.8892	782.2770
85	783.6575	785.0389	786.4215	787.8052	789.1984	790.5843	791.9712	793.3591	794.7482	796.1383
86	797.5296	798.9219	800.3066	801.7011	803.0966	804.4932	805.8909	807.2810	808.6808	810.0818
87	811.4751	812.8781	814.2736	815.6788	817.0763	818.4837	819.8834	821.2929	822.6947	824.0076
88	825.5704	826.9154	828.3214	829.7374	831.1456	832.5549	833.9652	835.3766	836.7890	838.2025
89	839.6171	841.0327	842.4494	843.8671	845.2854	846.7058	848.1267	849.5487	850.9627	852.3868
90	853.8120	855.2382	856.6564	858.0847	859.5051	860.9355	862.3670	863.7905	865.2241	866.6496
91	868.0763	869.5130	870.9417	872.3806	873.8114	875.2432	876.6761	878.1192	879.5541	880.9901
92	882.4272	883.8652	885.3044	886.7445	888.1857	889.6280	891.0712	892.5156	893.9609	895.4073
93	896.8548	898.3032	899.7528	901.1946	902.6456	904.0982	905.5519	906.9972	908.4530	909.9097
94	911.3582	912.8170	914.2675	915.7284	917.1809	918.6439	920.0985	921.5541	923.0202	924.4778
95	925.9365	927.4056	928.8664	930.3281	931.7908	933.2642	934.7290	936.1948	937.6616	939.1295
96	940.5984	942.0683	943.5392	945.0111	946.4841	947.9581	949.4331	950.9091	952.3764	953.8545
97	955.3336	956.8136	958.2948	959.7672	961.2503	962.7345	964.2099	965.6961	967.1735	968.6617
98	970.1412	971.6314	973.1129	974.6051	976.0886	977.5829	979.0684	980.5548	982.0522	983.5407
99	985.0302	986.5206	988.0220	989.5145	991.0080	992.5025	993.9980	995.4945	996.9920	998.4905
100	1000.0000	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .

CONVERSION FACTORS FOR UNITS OF VOLUME OF FLOW OF WATER

A	To Reduce A to B Multiply A by	To Reduce B to A Multiply B by	B
Cubic feet per second	60.0	0.0167	Cubic feet per minute
Cubic feet per second	86400.0	....	Cubic feet per 24 hours
Cubic feet per second	448.8	0.0023	United States gallons per minute
Cubic feet per second	646272.0	....	United States gallons per 24 hours
Cubic feet per second	1.96	0.510	Acre-feet per 24 hours
Cubic feet per second	40.0	0.025	California miner's inches
Cubic feet per second	38.4	0.026	Colorado miner's inches
Cubic feet per second	40.0	0.025	Arizona miner's inches
Cu. ft. per sec. per square mile	0.00155	645.2	Inches depth per hour
Cu. ft. per sec. per square mile	0.03719	26.88	Inches depth for 1 day
Cu. ft. per sec. per square mile	1.041	0.961	Inches depth for 28 days
Cu. ft. per sec. per square mile	1.116	0.893	Inches depth for 30 days
Cu. ft. per sec. per square mile	1.153	0.870	Inches depth for 31 days
Cu. ft. per sec. per square mile	13.572	0.074	Inches depth for 365 days
Inches per hour per acre	0.0833	12.0	Acre-feet per hour
Inches per hour per acre	60.5	0.0165	Cubic feet per minute
Inches per hour per acre	1.0	1.0	Cubic feet per second
Cubic feet per minute	7.48	0.1337	United States gallons per minute
Cubic feet per minute	10771.0	....	United States gallons per 24 hours
Cubic feet per minute	0.0330	30.30	Acre-feet per 24 hours
California miner's inches	1.041	0.96	Arizona miner's inches
United States gallons per minute	1440.0	0.0006944	United States gallons per 24 hours
United States gallons per minute	0.0044	227.0	Acre-feet per 24 hours
United States gallons	0.8333	1.201	British Imperial gallons, 24 hours
United States gallons	....	325850.0	Acre-feet
United States gallons per 24 hours	5.348	0.187	California miner's inches
United States gallons per 24 hours	5.128	0.195	Colorado miner's inches
United States gallons per 24 hours	5.348	0.187	Arizona miner's inches
Cubic feet	....	43560.0	Acre-feet
1 million United States gallons	133690.0	....	Cubic feet
1 million United States gallons	0.325850	3258.0	Acre-feet
Cubic meters per second	35.215	0.028	Cubic feet per second

STORAGE AND VOLUME

1 Acre-foot = 43,560 cu. ft.
1 Acre-inch = 3,630 cu. ft.
1 Foot depth on 1 sq. mile = 27,878,400 cu. ft.
1 Inch depth on 1 sq. mile = 2,323,200 cu. ft.
1 Foot depth on 1 sq. mile = 640.0 acre-ft.
1 Inch depth on 1 sq. mile = 53.33 acre-ft.
1 Cu. ft. per sec. for 24 hours = 1 cu. ft. per sec. day = 86,400 cu. ft.
1 Cu. ft. per sec. day = 1.96 acre-ft.
1000 Cu. ft. per sec. days will supply 33.3 cu. ft. per sec. for 30 days

PRESSURE

1 Atmosphere = 760 mm. of mercury at 0 deg. C., at sea level
1 Atmosphere = 29.912 inches of mercury
1 Atmosphere = 33.9 ft. of water
1 Atmosphere = 14.697 lb. per sq. in.
1 Atmosphere = 2,117 lb. per sq. ft.
Pressure of water per sq. ft. = Depth feet = 62.4
Pressure of water per sq. in. = Depth feet × 0.433
Head of water in feet = lb. per sq. in. × 2.31

HORSEPOWER OF WATER

$$\text{Hp.} = \frac{62.4 \times \text{cu. ft. per min.} \times \text{Head in feet} \times \text{Efficiency}}{33{,}000}$$

$$\text{At } 80\% \text{ Efficiency, Hp.} = \frac{\text{cu. ft. per sec.} \times \text{Head}}{11}$$

At 75% Efficiency, Hp. = 0.0855 × Head × cu. ft. per sec.
At 80% Efficiency, Hp. = 0.0912 × Head × cu. ft. per sec.
At 85% Efficiency, Hp. = 0.0969 × Head × cu. ft. per sec.
At 90% Efficiency, Hp. = 0.1026 × Head × cu. ft. per sec.
At any % Efficiency, Hp. = 01135 × Efficiency × Head × cu. ft. per sec.
Water weighs 62.4 lb. per cu. ft.; 0.0361 lb. per cu. in.
Water weighs 8.34 lb. per gal.; 1685.0 lb. per cu. yd.

GENERAL ELECTRIC COMPANY

Sales Offices—Address nearest Office

Akron, Ohio .... 159 South Main Street
Amarillo, Tex. .... 806 South Grant Street
Atlanta, Ga. .... 187 Spring Street, Northwest
Baltimore, Md. .... 39 West Lexington Street
Binghamton, N. Y. .... 19 Chenango Street
Birmingham, Ala. .... 2031 First Avenue, North
Bluefield, W. Va. .... 307 Federal Street
Boston, Mass. .... 140 Federal Street
Buffalo, N. Y. .... 39 East Genesee Street
Butte, Mont. .... 20 West Granite Street
Canton, Ohio .... 700 Tuscarawas Street, West
Charleston, W. Va. .... 304 Capitol Street
Charlotte, N. C. .... 200 South Tryon Street
Chattanooga, Tenn. .... 536 Market Street
Chicago, Ill. .... 230 South Clark Street
Cincinnati, Ohio .... 215 West Third Street
Cleveland, Ohio .... 925 Euclid Avenue
Columbus, Ohio .... 17 South High Street
Dallas, Tex. .... 1801 North Lamar Street
Davenport, Iowa .... 511 Pershing Avenue
Dayton, Ohio .... 25 North Main Street
Denver, Colo. .... 650 Seventeenth Street
Des Moines, Iowa .... 418 West Sixth Avenue
Detroit, Mich. .... 700 Antoinette Street
Duluth, Minn. .... 14 West Superior Street
El Paso, Tex. .... 109 North Oregon Street
Erie, Pa. .... 10 East Twelfth Street
Fort Wayne, Ind. .... 1635 Broadway
Fort Worth, Tex. .... 410 West Seventh Street
Grand Rapids, Mich. .... 148 Monroe Avenue, Northwest
Hartford, Conn. .... 18 Asylum Street
Houston, Tex. .... 1016 Walker Avenue
Indianapolis, Ind. .... 110 North Illinois Street
Jackson, Mich. .... 212 Michigan Avenue, West
Jacksonville, Fla. .... 11 East Forsyth Street
Kansas City, Mo. .... 1004 Baltimore Avenue
Knoxville, Tenn. .... 602 South Gay Street
Los Angeles, Calif. .... 5201 Santa Fe Avenue
Louisville, Ky. .... 455 South Fourth Street
Memphis, Tenn. .... 8 North Third Street
Miami, Fla. .... 25 Southeast Second Avenue
Milwaukee, Wis. .... 940 West St. Paul Avenue
Minneapolis, Minn. .... 107 South Fifth Street
Nashville, Tenn. .... 234 Third Avenue, North
Newark, N. J. .... 20 Washington Place
New Haven, Conn. .... 129 Church Street
New Orleans, La. .... 837 Gravier Street
New York, N. Y. .... 120 Broadway
Niagara Falls, N. Y. .... 201 Falls Street
Oklahoma City, Okla. .... 15 North Robinson Street
Omaha, Nebr. .... 409 South Seventeenth Street
Philadelphia, Pa. .... 1405 Locust Street
Phoenix, Ariz. .... 11 West Jefferson Street
Pine Bluff, Ark. .... 501 Main Street
Pittsburgh, Pa. .... 535 Smithfield Street
Portland, Oreg. .... 329 Alder Street
Providence, R. I. .... 76 Westminster Street
Richmond, Va. .... 700 East Franklin Street
Roanoke, Va. .... 202 South Jefferson Street
Rochester, N. Y. .... 89 East Avenue
St. Louis, Mo. .... 112 North Fourth Street
Salt Lake City, Utah .... 200 South Main Street
San Antonio, Tex. .... 201 Villita Street
San Francisco, Calif. .... 235 Montgomery Street
Schenectady, N. Y. .... 1 River Road
Seattle, Wash. .... 821 Second Avenue
Shreveport, La. .... 513 Marshall Street
Spokane, Wash. .... 421 Riverside Avenue
Springfield, Ill. .... 504 East Monroe Street
Springfield, Mass. .... 1387 Main Street
Syracuse, N. Y. .... 113 South Salina Street
Tacoma, Wash. .... 1019 Pacific Avenue
Tampa, Fla. .... 604 Ella Mae Street
Terre Haute, Ind. .... 701 Wabash Avenue
Toledo, Ohio .... 405 Madison Avenue
Trenton, N. J. .... 143 East State Street
Tulsa, Okla. .... 409 South Boston Street
Utica, N. Y. .... 258 Genesee Street
Washington, D. C. .... 800 Fifteenth Street, Northwest
Waterbury, Conn. .... 195 Grand Street
Wheeling, W. Va. .... 40 Fourteenth Street
Worcester, Mass. .... 340 Main Street
Youngstown, Ohio .... 16 Central Square

Canada: Canadian General Electric Company, Ltd., Toronto
Hawaii: W. A. Ramsay, Ltd., Honolulu
Motor Dealers and Lamp Agencies in all large cities and towns

SERVICE SHOPS

Atlanta, Ga. .... 496 Glenn Street, Southwest
Buffalo, N. Y. .... 318 Urban Street
Chicago, Ill. .... 509 East Illinois Street
Cincinnati, Ohio .... 215 West Third Street
Cleveland, Ohio .... 1133 East 152nd Street
Dallas, Tex. .... 1801 North Lamar Street
Detroit, Mich. .... 700 Antoinette Street
Kansas City, Mo. .... 819 East Nineteenth Street
Los Angeles, Calif. .... 5203 Santa Fe Avenue
Milwaukee, Wis. .... 940 West St. Paul Avenue
Minneapolis, Minn. .... 410 Third Avenue, North
New York, N. Y. .... 416 West Thirteenth Street
Philadelphia, Pa. .... 429 North Seventh Street
Pittsburgh, Pa. .... 16 Terminal Way
St. Louis, Mo. .... 1009 Spruce Street
Salt Lake City, Utah .... 360 West Second South Street
San Francisco, Calif. .... 340 First Street
Seattle, Wash. .... 1508 Fourth Avenue, South

Special service divisions are also maintained at the following works of the Company: Erie, Pa.; Ft. Wayne, Ind.; Oakland, Calif; Pittsfield, Mass.; Schenectady, N. Y.; and West Lynn, Mass—River Works and West Lynn Works.

BROADCASTING STATIONS

WGY, Schenectady, N. Y.
KOA, Denver, Colo.
KGO, Oakland, Calif.
Short Wave Stations
W2XAD—Schenectady
W2XAF—Schenectady

INTERNATIONAL GENERAL ELECTRIC COMPANY, INC.

Executive Offices: 120 Broadway, New York City **SCHENECTADY, N. Y.** Cable Address: "Ingenetric New York"

FOREIGN OFFICES, ASSOCIATED COMPANIES, AND AGENTS

ARGENTINA: General Electric, S.A., Buenos Aires, Cordoba, Rosario de Santa Fe, Tucuman, and Mendoza
AUSTRALIA: Australian General Electric Company, Ltd., Sydney, Melbourne, Adelaide, Brisbane, Newcastle, Queensland, Rockhampton, Maffra, Colac, Townsville, Canberra, Albury, and Lismore
BELGIUM AND COLONIES: Societe d'Electricite et de Mecanique (Procedes Thomson-Houston & Carels) Societe Anonyme, Brussels, Belgium
BRAZIL: General Electric, S.A., Rio de Janeiro, Sao Paulo, Bahia, Porto Alegre, Bello Horizonte, Juiz de Fora, Belem, Curityba, Santos, and Recife
CENTRAL AMERICA: International General Electric Co., Inc., Panama City, Panama; Guatemala City, Guatemala; New Orleans, La.
CHILE: International Machinery Company, Santiago, Antofagasta and Valparaiso, Nitrate Agencies, Ltd., Iquique
CHINA: Andersen, Meyer & Company, Ltd., Shanghai; China General Edison Company, Shanghai
COLOMBIA: International General Electric, S.A., Barranquilla, Bogota, Medellin, and Cali
CUBA: General Electric Company of Cuba, Havana, and Santiago de Cuba
ECUADOR: Guayaquil Agencies Co., Guayaquil
EGYPT: British Thomson-Houston Company, Ltd., Cairo
FRANCE AND COLONIES: Compagnie Francaise Thomson-Houston, Paris; International General Electric Co., Inc., Paris; Compagnie Des Lampes, Paris
GERMANY: H. B. Peirce, Representative, General Electric Co., Berlin
GREAT BRITAIN AND IRELAND: International General Electric Co., Inc., British Thomson-Houston Co., Ltd., London, W.C.2; British Thomson-Houston Co., Ltd., Rugby
GREECE AND COLONIES: Compagnie Francaise Thomson-Houston, Paris, France
HOLLAND: Mijnssen & Co., Amsterdam
INDIA: International General Electric Company, Inc., Calcutta, Bombay and Bangalore
ITALY AND COLONIES: Compagnia Generale Di Elettricita, Milan
JAPAN: Shibaura Engineering Works, Tokyo; Tokyo Electric Company, Ltd., Kawasaki, Kanagawa-Ken; International General Electric Co., Inc., Tokyo
JAVA: International General Electric Co., Inc., Soerabaia
MEXICO: General Electric, S.A., City of Mexico, Guadalajara, Monterrey, Vera Cruz and El Paso, Texas
NEWFOUNDLAND: International General Electric Co., Inc., St. Johns
NEW ZEALAND: National Electrical and Engineering Company, Ltd., Auckland, Dunedin, Christchurch and Wellington
PARAGUAY: General Electric, S.A., Buenos Aires, Argentina
PERU: International Machinery Co., Lima
PHILIPPINE ISLANDS: Pacific Commercial Company, Manila; International General Electric Co., Inc., Manila
PORTO RICO: International General Electric Company of Porto Rico, San Juan
PORTUGAL AND COLONIES: Sociedade Iberica de Construcoes Electricas Lda., Lisbon
SOUTH AFRICA: South African General Electric Company, Ltd., Johannesburg, Capetown, Durban, and Port Elizabeth
SPAIN AND COLONIES: Sociedad Iberica de Construcciones Electricas, Madrid, Barcelona, Bilbao, Valladolid, and Sevilla
SWITZERLAND: Trolliet Freres, Geneva
URUGUAY: International General Electric, S.A., Montevideo
VENEZUELA: International General Electric, S.A., Caracas and Maracaibo

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